

CHAPTER TWO

NATIONAL IMPACTS OF THE YUCCA MOUNTAIN PROGRAM

While the physical location for the proposed Yucca Mountain repository is within the State of Nevada, the impacts of DOE's high-level nuclear waste program reach well beyond the confines of one state. In fact, the national impacts of this project would far surpass in magnitude and scope those that are specific to Nevada, although the Nevada impacts, as documented in subsequent chapters of this report, would, of themselves, be enormous. Ironically, while the efforts made by DOE to understand risks and impacts to Nevada have been minimal and inadequate, even less has been done to assess the effects of this massive and unprecedented program on the country as a whole.

Of all the impacts associated with the Yucca Mountain program, none are as far-reaching and pervasive as those related to the transportation of SNF and HLW. Tens of thousands of shipments of extremely dangerous radioactive waste would impact 44 states, hundreds of cities, and thousands of communities, day after day, week after week, month after month for 38 years or more. Transportation would be the principal cause of impacts ranging from losses in property values to depressed economic activity to escalating and unfunded preparedness and response costs to social disruption and even civil unrest. The risk of a public health and economic catastrophe following a severe accident or terrorist incident would persist daily for the life of the shipping campaign for hundreds of vulnerable metropolitan areas nationwide.

In addition to the tremendous national transportation implications, the cost impacts of the Yucca Mountain program will be considerable, even for the budget of the federal government. Costs of the program have escalated in just three years from approximately \$28 billion to over \$59 billion (and may eventually be as high as \$75 billion), while the funding mechanism established to pay for it - the fees levied on nuclear-generated electricity - continues to face major uncertainties due to a diminishing revenue base. With an unfunded taxpayer liability of between \$17 and \$34 billion, the DOE HLW program represents a fiscal time bomb for future federal budgets.

Finally, the damage Yucca Mountain would inflict on future state-federal relations would be considerable. A decision by the President to forge ahead with this transparently flawed project in the face of Nevada's strong, long-standing, consistent, legitimate, and scientifically based opposition would have damaging consequences for the nature and shape of American federalism now and in the future, as the nation pursues solutions to other difficult problems involving hazardous facilities and controversial technologies.

A more comprehensive analysis of these issues is contained below. However, the mere fact that DOE has not considered such crucial areas of national impact is reason, by itself, for the President to reject a decision to forge ahead with the flawed Yucca Mountain program.

2.1 National High-Level Waste Transportation Impacts

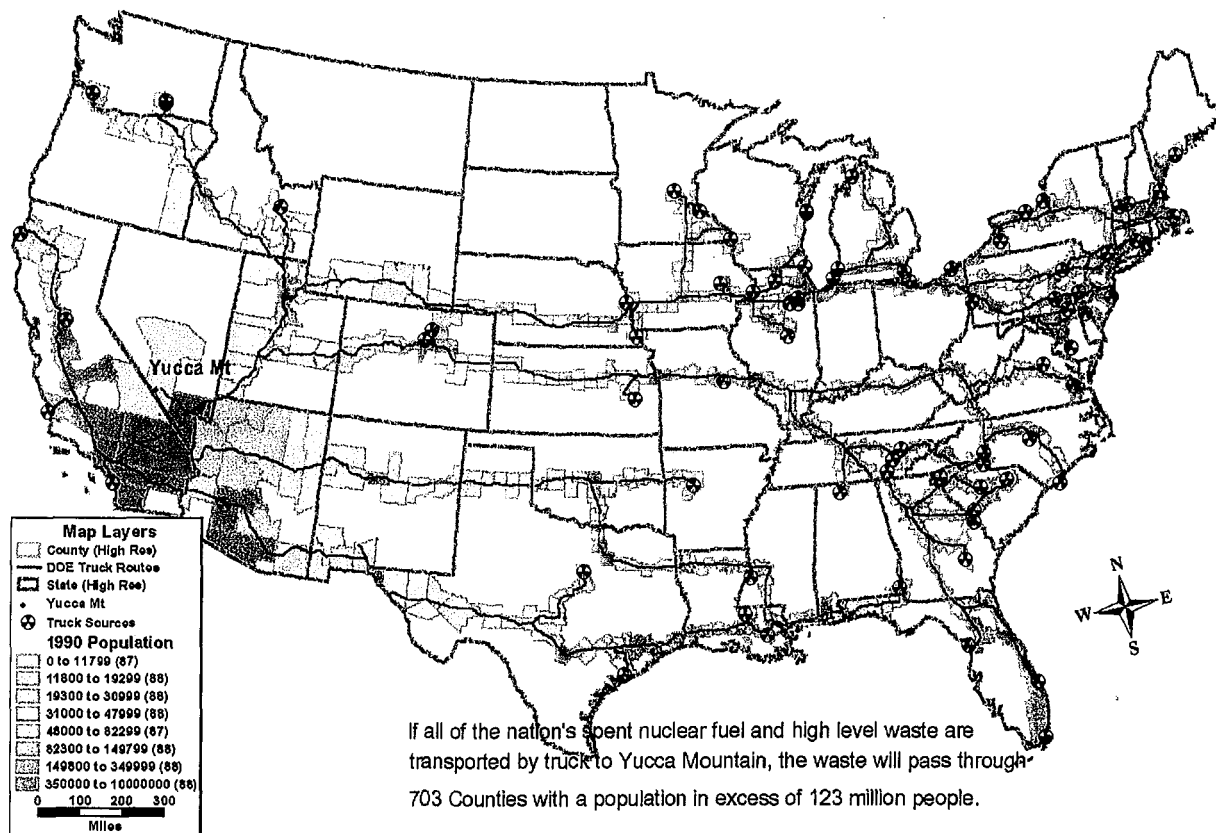
The transportation of spent nuclear fuel and high-level radioactive waste to a Yucca Mountain repository would require an effort of truly epic proportions. More radioactive waste would be shipped in the first full year of repository operations than has been transported in the entire five-decade history of spent fuel shipments in the United States. Shipments from 77 reactor and storage sites in 39 states would travel America's most important east-west interstate highways and mainline railroads. In all, 43 states, besides Nevada, would be directly impacted, including at least 109 cities with populations exceeding 100,000, hundreds of smaller cities, and thousands of communities.

Development of Yucca Mountain would unleash a continental nuclear waste shipping campaign of completely unprecedented size and duration. With these shipments would come a constellation of hazards and risks, including elevated radiation exposures to workers and the public from routine transportation activities; risk of credible severe accidents capable of contaminating tens of square miles, requiring billions of dollars in cleanup costs to prevent thousands of latent cancer fatalities; heightened vulnerability to terrorism and sabotage in metropolitan areas; and significant economic damage and property value losses in cities and communities along shipping routes, even if no severe accidents occur.

Under the only transportation scenario currently feasible, there would be up to 96,000 cross-country truck shipments over 38 years. The most likely truck routes to Yucca Mountain are shown in Figure 2.1.1. The "mostly truck" scenario would affect 44 states, including Nevada. For 38 years, truck shipments to Yucca Mountain would be a daily occurrence. The routes pass through 703 counties with a population in excess of 123 million people. More than 7 million people live within one-half mile of these highway routes.

Figure 2.1.1

Counties Affected by Truck Transportation to Yucca Mt.

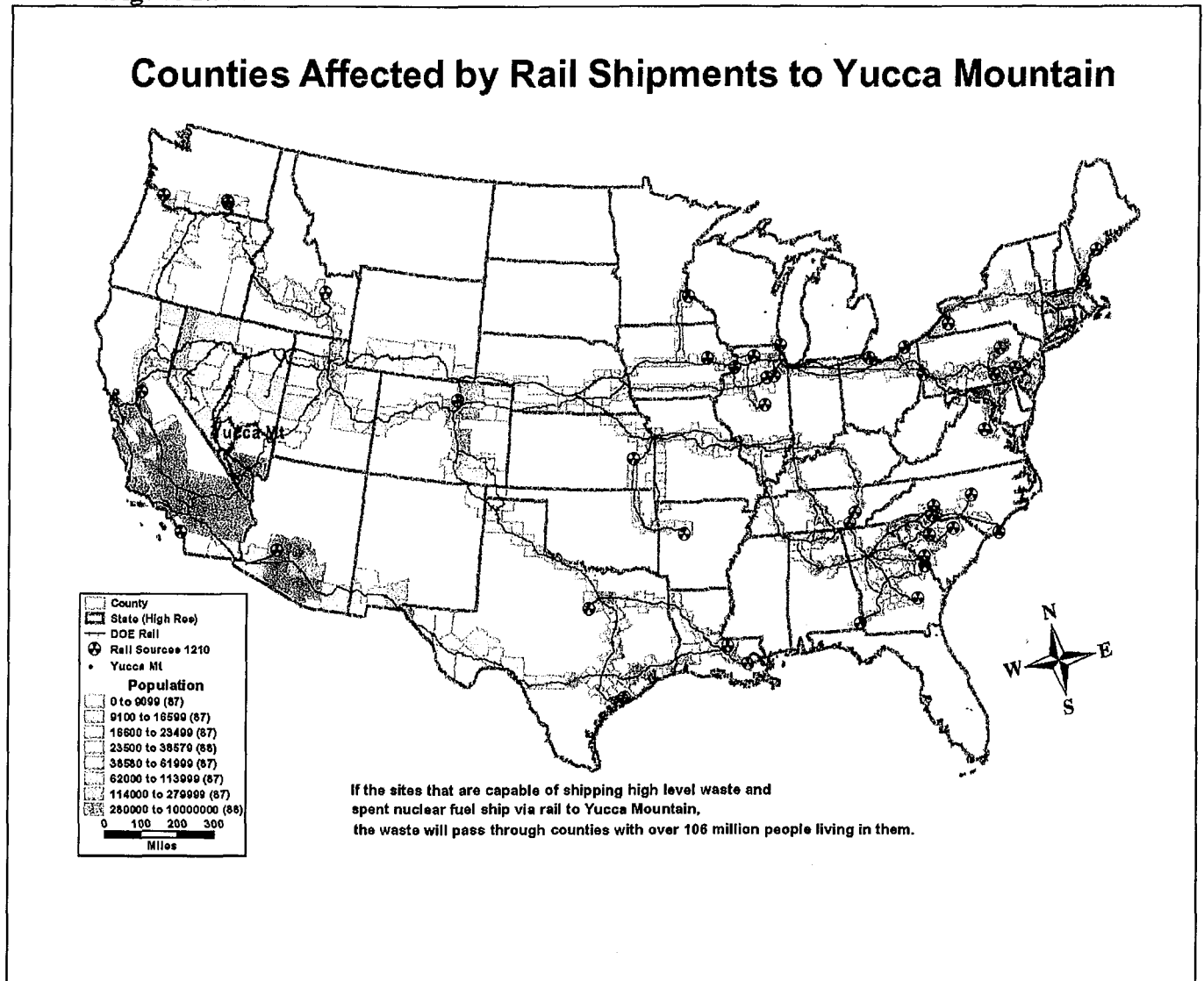


The use of rail as a mode of transport to Yucca Mountain is problematic for several reasons. First, there is no rail access to the Nevada site and providing such access would require construction of anywhere from over 100 miles to almost 500 miles of new rail line at a cost of over \$1 billion. Second, many of the nuclear power plant sites either lack rail access altogether or lack the capability to handle very large rail shipping casks. Rail shipments would require major infrastructure expenditures at numerous facility sites, an unprecedented use of heavy-haul truck and/or barge transportation to move casks to a useable railhead, or both. For these reasons, rail shipments to Yucca Mountain are not considered viable at this time.

However, if rail shipments became feasible, according to State of Nevada estimates, 40,300 shipments would be required. The most likely rail routes to Yucca Mountain from sites that can presently ship by rail are shown in Figure 2.1.2. DOE's plan

would route rail shipments through 43 states. The rail routes pass through counties with a combined population over 106 million. More than 11 million people live within one-half mile of DOE's proposed rail routes.

Figure 2.1.2



National Transportation Overview

Recent Spent Nuclear Fuel Shipments

During the past two decades, nuclear power plants and research facilities in the United States have made relatively few off-site shipments of irradiated reactor fuel, more commonly referred to as spent nuclear fuel (SNF). The U.S. Nuclear Regulatory Commission (NRC) regulates such shipments and maintains a detailed SNF shipment database. Between 1979 and 1997, the most recent period reported by NRC, there were

1,334 domestic shipments containing 1,453 metric tons uranium (MTU) of civilian SNF. Table 2.1.1 summarizes significant characteristics of these shipments.

Table 2.1.1 U.S. Civilian SNF Shipment Experience, 1979 - 1997¹

Amount Shipped	1,453 MTU (76.5 MTU per year)
Total Shipments	1,334 (70 per year)
Truck Shipments	1,181 (62 per year)
Rail Shipments	153 (8 per year)
Truck Share of SNF Shipments	88.5%
Rail Share of MTU Shipped	75.5%
Average Truck Shipment Distance	684 miles (82%<900 miles)
Average Rail Shipment Distance	327 miles (80%<600 miles)
Shipment Origin & Destination	70% East of Mississippi River (935/1334)
Number of Reactor Sites Making One or More Shipments	27 (9 sites>2 shipments)

Source: NRC, NUREG-0725, Rev. 13 (October 1998)

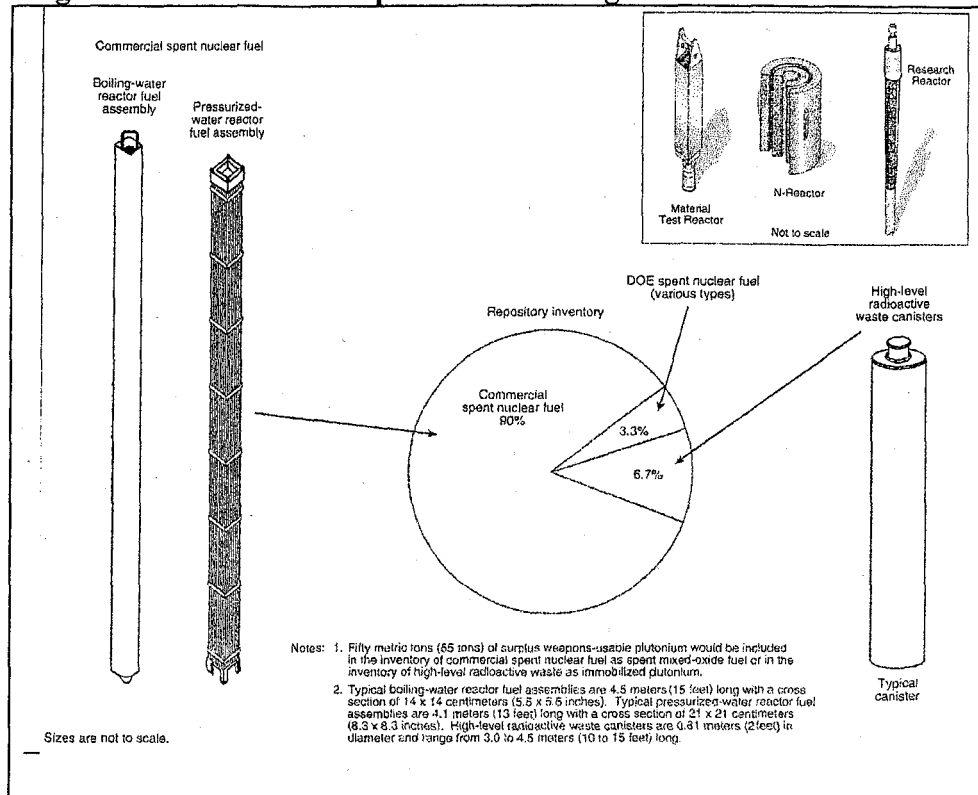
Radiological Hazards of High-Level Radioactive Waste

SNF from commercial power reactors will comprise about 90 percent of the radioactive wastes shipped to a geologic repository. About two-thirds of the SNF will come from pressurized water reactors (PWRs), the remainder from boiling water reactors (BWRs). Figure 2.1.3 shows PWR and BWR fuel assemblies.

Both types of SNF will be highly radioactive for thousands of years and thermally hot for hundreds of years. Nuclear fission inside the reactors transforms some of the original uranium fuel into isotopes of uranium, plutonium and other transuranic elements, and fission products such as strontium-90 and cesium-137. Fission products account for most of the radioactivity in SNF for the first hundred years after removal from reactors. Fission products, which emit both beta and gamma radiation, are the primary sources of exposure during routine transportation operations and the major potential source of irradiation and contamination in the event of a severe transportation accident or successful terrorist attack.

¹ During the same period, the U.S. Department of Energy made several dozen shipments of Three Mile Island reactor core debris and intact commercial reactor SNF. These shipments were not regulated by NRC and were therefore not included in the NRC database. There were also an undisclosed number of naval reactor fuel shipments, estimated at several hundred.

Figure 2.1.3 Sources of Spent Fuel and High-level Waste



When first removed from a reactor core, SNF is so radioactive that it delivers a lethal dose of radiation in seconds. It must be cooled in water-filled storage basins for a minimum of 3-5 years before it can be loaded into a truck transport cask. It must be cooled 10 years before it can be loaded into a rail transport cask or into a dry storage cask or canister. After 50 years of cooling, SNF can still deliver a lethal radiation exposure in minutes. Table 2.1.2 summarizes the two most important radiological characteristics for assessing SNF transportation risks, total activity and surface dose rate, as a function of cooling time or age. The exposure time for a lethal dose (600 rem) from unshielded SNF is less than one minute after 5 years, less than 2 minutes after 10 years, and less than 5 minutes after 50 years.

Table 2.1.2 Radiological Characteristics of Commercial Spent Nuclear Fuel

SNF Age (Years Cooled)	Total Activity (Curies)	Surface Dose Rate (Rem/Hour)
1	2,500,000	234,000
5	600,000	46,800
10	400,000	23,400
50	100,000	8,640

Source: U.S. DOE, DOE/NE-0007, 1980.

High-level radioactive waste (HLW) from atomic weapons production and reprocessing of commercial SNF will make up about 7 percent of the waste inventory shipped to the repository. Figure 2.1.4 shows a representative HLW canister. Because each stainless steel canister of HLW borosilicate glass will contain thousands of curies of cesium-137, strontium-90, and other fission products, HLW will remain a lethal source of gamma and neutron radiation for many decades.

SNF and HLW Inventories to be Shipped to the Repository

SNF is presently stored at 72 utility sites and 5 DOE facilities in 34 states. HLW is presently stored at 4 DOE facilities in Idaho, New York, South Carolina, and Washington. About 80 percent of the SNF from civilian power plants is presently stored at sites east of the Mississippi River.

Over the next five decades, SNF and HLW containing the equivalent of more than 119,000 metric tons of heavy metal (MTHM) will be shipped to the repository.² These quantities are shown in Table 2.1.3, along with other radioactive wastes that will go to the repository. Greater-Than-Class-C (GTCC) waste is so-called low-level radioactive waste that cannot be disposed in shallow land-burial facilities. Special-Performance-Assessment-Required (SPAR) wastes include reactor operating and decommissioning wastes, isotope production wastes, naval reactor components, sealed radioisotope sources, and fuel assembly hardware.

Table 2.1.3 Projected Inventory of Radioactive Wastes To Be Shipped To A Repository, 2010 - 2048.

Waste Type	MTHM	Units	Volume (cubic meters)	Mass (metric tons)
Commercial SNF	105,414	359,963 (assemblies)	47,000	161,000 (estimate)
HLW	11,150	22,280 (canisters)	21,000	58,000
DOE SNF	2,500	210,000 (assemblies, bundles, cans, etc.)	1,900	8,150
GTCC		1,096 (truckloads)	2,060	
SPAR		2,010 (truckloads)	3,990	

Source: U.S. DOE, DOE/EIS-0250D, 1999, Appendices A & J

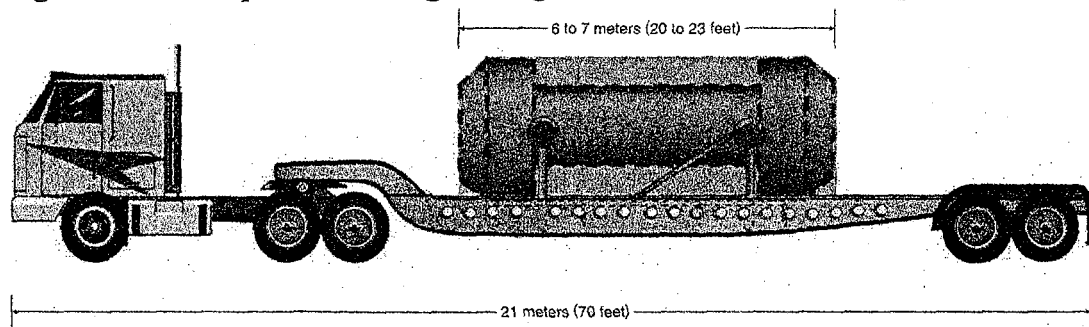
² The term metric tons of heavy metal (MTHM) refers to the initial amount of uranium, plutonium, or thorium in the fuel assembly before insertion into a reactor core. It may also be referred to as metric tons of uranium (MTU) or metric tons of initial heavy metal (MTIHM). In addition to uranium or mixed oxide fuel pellets, fuel assemblies contain a considerable amount of zirconium and stainless steel components. A pressurized water reactor (PWR) fuel assembly containing 0.46 MTU has a total weight of 0.66 metric tons. A boiling water reactor (BWR) fuel assembly containing 0.18 MTU has a total weight of 0.32 metric tons. Regarding HLW, the term MTHM historically refers to an estimated curie content equivalent. Each canister of commercial HLW was estimated to contain 2.3 MTHM, and each canister of defense HLW was estimated to contain the equivalent of 0.5 MTHM. Because DOE now uses a variety of calculation methods, the estimated MTHM equivalent of HLW is less meaningful than the estimated number of HLW canisters.

SNF and HLW Shipping Casks

Most of the shipping casks currently used by the nuclear industry were designed in the 1970s and have limited payload capacity. For repository shipments, DOE plans to use new designs that will increase truck cask capacity from 0.5 MTHM to 2.0 MTHM, and increase rail cask capacity from 3.5 MTHM to 10-12 MTHM. Some of the new rail casks are for transport only; others are so-called dual-purpose casks that can be used for transport or storage. The NRC has certified several new designs, but none of the new casks have yet been constructed. Contrary to inferences by DOE and the commercial nuclear power industry, there is no requirement that full-scale casks be physically tested.

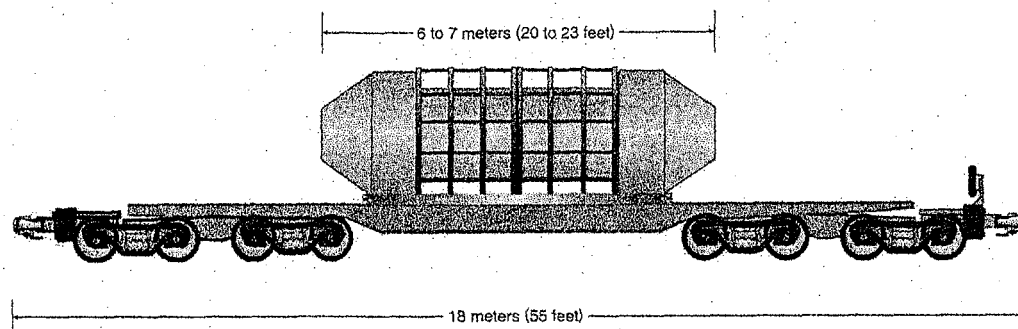
Figure 2.1.4 shows a conceptual drawing of a new legal-weight truck cask and vehicle transporter system. Figure 2.1.5 shows a conceptual drawing of a new high-capacity rail cask on a rail car.

Figure 2.1.4 Proposed New Legal-Weight Truck Cask and Transporter



Source: Kalkreuthaus (1999, page 7).

Figure 2.1.5 Proposed New High-Capacity Rail Cask

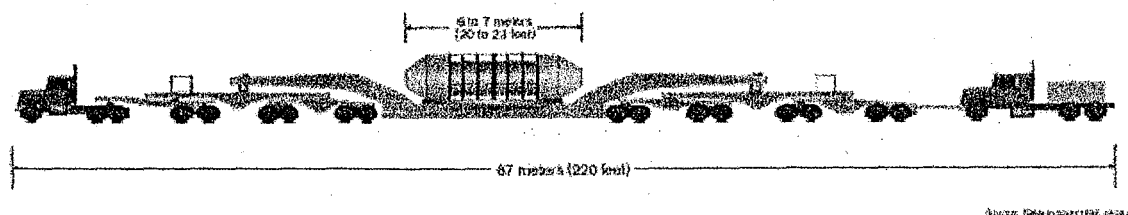


Source: Kalkreuthaus (1999, page 8).

Legal-weight truck (LWT) casks are designed so that the total loaded weight of the truck does not exceed 40 tons. Compliance with this weight restriction facilitates routing across the federal highway system. Some of the new rail cask designs have a loaded weight of 160 tons or more. Weight restrictions on some rail routes and bridges will limit use of the largest casks. At reactor sites that lack rail access, DOE is considering moving these large casks to railheads by barge or by heavy-haul truck (HHT). DOE is also considering moving these casks by HHT in Nevada. The weight of

the larger rail casks may seriously complicate HHT transport on public highways. HHT transport utilizes a rig 220 feet long, including a pulling diesel tractor, a long trailer with 12 to 16 axles, and a pushing tractor. Figure 2.1.6 shows a conceptual drawing of HHT transport of a large rail cask. HHT shipments also require state permits and operate under time-of-day and other restrictions. There is no actual experience with long-distance HHT transport of such SNF casks in the United States.

Figure 2.1.6 Proposed HHT Transport Cask and Vehicle Configuration



SNF Transportation Modal Choice Options

In the Yucca Mountain DEIS, DOE has taken the position that there is no significant difference between rail and truck transportation risks and impacts. Most stakeholders that have taken a position on this issue believe that a properly designed rail transportation system is preferable. When pressed on the issue in DEIS public meetings, DOE representatives generally stated that DOE would attempt to maximize use of rail, primarily for the purpose of reducing the overall number of shipments. A review of the factors that will determine modal mix suggests that it will be difficult and impractical to maximize use of rail transportation.

Transportation conditions in Nevada will make direct rail delivery difficult. Yucca Mountain lacks rail access at present. Each one of the five potential rail access routes identified in the DEIS involves significant land use conflicts and adverse environmental impacts. Ranging in length from about 100 miles to 320 miles, even the shortest access spur route to Yucca Mountain would be the largest new rail construction project in the United States since World War I. Many operating assumptions and design details are uncertain. Environmental approvals, right-of-way acquisition, and litigation could delay completion for years. Construction costs would exceed \$1 billion.

The only other way to utilize national rail transportation as the principal mode for SNF and HLW shipments would be to construct an intermodal transfer facility somewhere along a main line railroad in proximity to Yucca Mountain and use HHT transport from the intermodal facility to the site. However, transportation conditions in Nevada are extremely unfavorable for HHT transport of large rail casks. There are no existing facilities capable of transferring large rail casks (up to 180 tons) to HHTs. Each one of the three sites identified by DOE for potential new intermodal transfer facilities would involve long-distance (120 to 230 mile) HHT shipments on public highways. Route constraints include congested segments through highly populated areas, and steep grades and sharp curves through mountain passes. DOE's proposal for daily SNF and

HLW shipments using 220 foot-long rigs is unprecedented in the United States, and safety issues are largely unknown. HHT costs could exceed rail spur construction and operation. State permit requirements and regulatory restrictions make the feasibility of HHT transport highly uncertain.

Conversely, transportation conditions at many nuclear reactor sites favor use of LWT. All existing reactors and DOE sites can ship by LWT, while 30 or more sites will have difficulty shipping by rail. Even DOE's most optimistic rail shipment plan assumes that nine sites in six states must ship by LWT, and another 18 sites in 13 states must use barges or HHTs to deliver rail casks to the nearest railhead. However, DOE has not addressed the institutional barriers or costs associated with HHT transport from reactors, or barge transport of SNF into Baltimore, Wilmington, Miami, Milwaukee, and other port cities.

Moreover, certain programmatic and policy factors favor shipment by LWT, especially during the first 10-15 years of repository operations. These factors include:

- DOE's "hot repository" thermal loading strategy (which may require LWT shipment of 5-year-cooled SNF);
- The decision by some utilities to exercise contract options to ship 5-year-cooled SNF from storage pools by LWT, rather than shipping older SNF by rail; and
- DOE's current privatization plan, which does not require transportation providers to ship oldest fuel first or to maximize use of rail. Indeed, under DOE's fixed-cost contract approach to privatization, rail transportation may not be cost-competitive with LWT at many sites.

Transportation System Assumed for This Impact Report - Key Assumptions

In order to evaluate the risks and impacts of the proposed SNF and HLW national transportation system, it was necessary to use certain assumptions to deal with the dizzying array of uncertainties and inadequacies in DOE's plans. This report assumes that the entire projected SNF and HLW inventory (presently about 120,000 MTHM) will be shipped to Yucca Mountain over about 38 years, beginning in 2010. The report also assumes the following:

- (1) If no rail spur to Yucca Mountain is constructed, the most probable national transportation scenario is the DEIS "Mostly Truck" scenario - about 93,000 LWT shipments of SNF and HLW, plus about 3,000 LWT shipments of "miscellaneous wastes" (GTCC and SPAR). This means about 2,526 truck shipments per year, plus 300 rail shipments of naval reactor SNF.
- (2) If a rail spur is constructed, the most probable national transportation scenario is the State of Nevada "Current Capabilities" scenario - about 26,400 LWT shipments of civilian SNF (40% of MTHM) from 32 sites, 8,200 rail cask-

shipments of civilian SNF (60% of MTHM) from 40 sites, and 5,900 rail cask shipments from 5 DOE sites. This means about 1,066 shipments per year.

- (3) The DOE "Mostly Rail" scenario is highly improbable, but this report evaluates it because of what it represents for certain worst case impacts.
- (4) The DOE proposal for HHT transport of large rail casks from an intermodal transfer facility is highly improbable, but for certain worst case impacts it will be evaluated.
- (5) The base case cross-country rail and highway routes identified in the DEIS will be assumed for this report.
- (6) Four Nevada rail spur alternatives (excluding Caliente-Chalk Mountain) will be considered technically feasible. These four alternatives have different implications for national rail routing.
- (7) The report assumes the status quo regarding regulations and safety/security practices. Therefore, this report assumes no full-scale physical cask testing; no required use of dedicated trains (i.e., all casks are shipped singly in general freight service); no additional safety requirements; and enforcement of existing regulations and work rules at current levels.
- (8) The report assumes SNF is cooled only 5 years before truck or rail transport for worst case impacts. NRC regulations require 3-5 years for truck casks, 10 years for rail casks. DOE assumed 26 year-cooled in DEIS analyses.
- (9) The report assumes DOE contracts for private sector transportation services per the last transportation system privatization proposal.

National Transportation Routes To Yucca Mountain

The first step in assessing the national impacts of transportation to Yucca Mountain is the identification of the transportation modes and routes. Absent such identification, it is impossible to adequately assess the impacts of the shipping campaign on the country as a whole and on individual states and communities. In 1986, in response to state and local government concerns, DOE promised to provide the necessary information in the Environmental Assessments (EA) for potential repository sites:

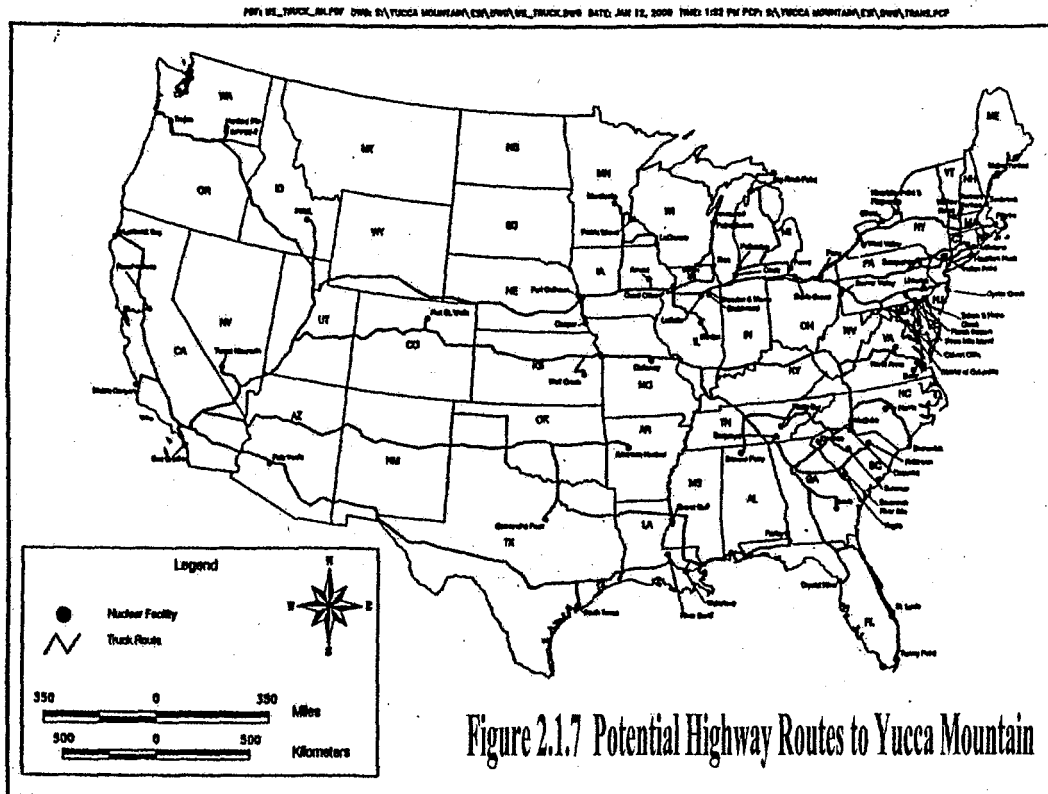
"The DOE believes that the general methods and national average data used [in the 1986 Environmental Assessments] are adequate for this stage of the repository siting process [i.e., the pre-site characterization stage]. Route-specific analyses and an evaluation of the impacts on host States and States along transportation corridors would be included in the environmental impact statement." [Comment Response Document, May, 1986, full citation in NWPO DEIS Comments, p.138]

DOE chose to ignore this promise when the Yucca Mountain Draft EIS was released in July 1999 and during most of the public comment period that followed. The DEIS does not identify the specific routes evaluated by DOE in Chapter 6 and Appendix J. DOE did not identify the routes in its Federal Register notice nor in its public notices of scheduled hearings. During the public hearings that began in September 1999, DOE provided some state-specific transportation maps at individual hearings around the country, but DOE did not release national maps showing the full cross-country routes from shipping sites to Yucca Mountain until sometime in late January 2000, near the end of the public comment process. Interestingly, the maps showing these routes were removed from the DOE website within a short time and have not since been made public.

The irony of the situation is that DOE has, in fact, done the analyses needed to reveal specific highway and rail routes that would be used for waste shipments and to conduct required impact assessments along those routes. That information, however, was buried in data used to run computer models and was never made explicit in the Draft EIS. The Draft EIS contained no maps or other information showing which cities and communities along transportation corridors would be affected by this massive and unprecedented radioactive waste shipping campaign. Nevada concluded that such an oversight can only be seen as intentional and designed to suppress public interest in the project and participation in these public hearings.

Figure 2.1.7 shows the highway routes evaluated, and then suppressed, in the DEIS. These routes were generated by the HIGHWAY computer model and represent the quickest truck travel routes consistent with the current federal routing regulations (HM-164). Ironically, the map is the same one DOE removed from its website shortly after it appeared during the last of the DEIS hearings. The routes shown in Figure 2.1.7 are the base case cross-country routes that connect the 77 shipping sites with Yucca Mountain.

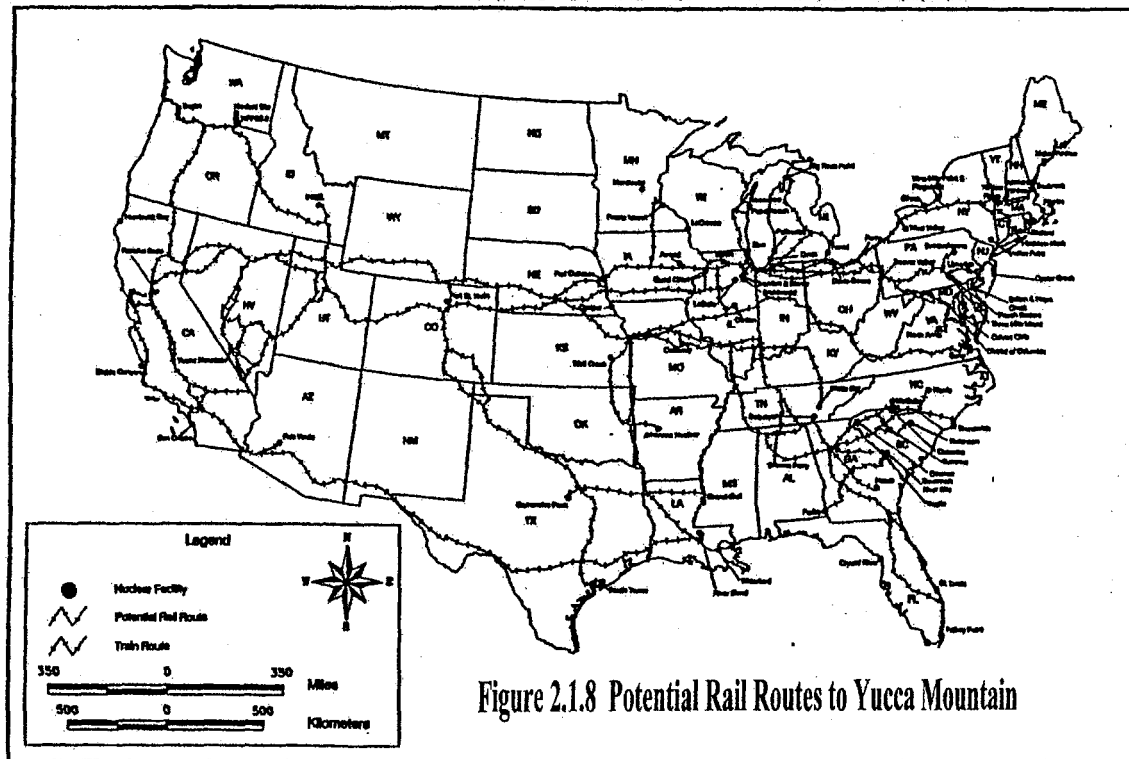
While the State of Nevada believes that DOE would not be able to use the planned I-215 Las Vegas Beltways, this does not affect the point of entry for shipments coming into Nevada. DOE's base case routes to the Yucca Mountain site generally agree with the highway routes identified in previous routing studies by DOE and Nevada contractors. Absent additional states' designations of preferred alternatives or DOE policy decisions, Nevada believes that these are the most likely highway routes to Nevada.



The primary truck routes out of New England and the Middle Atlantic states are I-90, I-80, I-76, and I-70. These routes converge on I-80/90 near Cleveland, pick up shipments from midwestern reactors, and follow I-80 west from Chicago through Des Moines, Omaha, Cheyenne, and Salt Lake City to I-15.

The primary truck routes out of the South are I-75 from Florida, I-24 from Atlanta, and I-64 from Virginia. These routes converge on I-70 near St. Louis and follow I-70 west through Kansas City and Denver to I-15 in Utah.

The primary route from the Pacific Northwest is I-84 to I-15 in Utah. Other major routes are I-40 and I-10 from the Mid-South and I-5 in California. These routes converge on I-15 in Southern California.



These routes represent the routes analyzed in Chapter 6 of the Draft Regulatory Environmental Impact Statement and may not be the routes actually used for shipments to a potential repository at Yucca Mountain. Train routes comply with U.S. Department of Transportation routing regulations. Rail routes are based on maximizing the degree of rail line touch and minimizing the overall distance and number of interchanges between railroads. Direction arrow is approximate.

Figure 2.1.8 shows the rail routes evaluated in the DEIS. These routes were generated by the INTERLINE computer model and generally represent the most direct routes to Nevada consistent with the current industry practice of maximizing freight-miles on the originating railroad. The map shows the cross-country rail routes for all five rail spur locations in Nevada.

DOE has not yet identified a preferred rail destination in Nevada. Both DOE and Nevada have used Caliente as a default location. Construction of a northern rail spur along the Union Pacific mainline between Salt Lake City and Reno would change the routing for about 10-20 percent of the rail shipments. Otherwise, the cross-country routes to Nevada are generally the same for the three southern rail spur options. The documentation for these routes is available on the DOE Yucca Mountain Project website.

Nevada believes that DOE's entire approach to rail transportation planning is deficient, and that DOE's "mostly rail" transportation scenario is unworkable. Nonetheless, DOE's base case rail routes to Nevada generally agree with the rail routes identified in previous routing studies by DOE and Nevada contractors. While mergers and other rail industry developments would continue to affect routing, Nevada believes that Figure 2.1.8 shows the most likely rail routes to Nevada.

The primary rail routes out of New England and the Middle Atlantic states would be the former Conrail mainlines from Buffalo and Harrisburg to Cleveland and Chicago. These shipments switch to the Union Pacific near Chicago, are joined by shipments from mid-western reactors in Illinois and Iowa, and continue west via Fremont, Gibbon, Cheyenne, and Salt Lake City to Nevada.

The primary routes out of the South would be the CSXT from Atlanta to East St. Louis, and the Norfolk Southern from Atlanta to Kansas City via Birmingham and Cairo. These two streams merge on the Union Pacific in Kansas City, and in turn merge with the northern UP shipments at Gibbon, Nebraska. Other major rail routes are the UP from Oregon via Boise, and the UP and BNSF from California and the Southwest via San Bernardino and Daggett.

Transportation Corridor States To Yucca Mountain

The DOE "mostly truck" and "mostly rail" transportation scenarios have been previously described above. The "mostly truck" scenario is currently feasible for all shipping sites and would require about 96,000 legal-weight truck shipments over 38 years. DOE's "mostly rail" scenario, which is feasible only if a new rail spur is constructed in Nevada and DOE is able to ship rail casks from 18 - 30 difficult sites, would require about 19,800 rail shipments and 3,700 legal-weight truck shipments over 38 years. In order to get the rail casks from 18 reactors to railroads, DOE proposes about 3,980 heavy-haul truck (HHT) shipments, or a combination of about 2,250 barge shipments and 1,000 HHT shipments.

Table 2.1.4 shows the potential numbers of shipments through various states under the "mostly truck" and "mostly rail" scenarios. (Note that shipment column entries cannot be totaled because each shipment goes through more than one state).

The "mostly truck" scenario affects 44 states, including Nevada. Nineteen states would be traversed by more than 13,900 shipments, an average of 366 shipments per year. Thirty-seven states would be traversed by more than 1,980 shipments, or 52 shipments per year. Put another way, for 38 years, truck shipments to Yucca Mountain would be a daily occurrence in 19 states, and a weekly occurrence in 37 states.

Table 2.1.4

POTENTIAL SHIPMENTS TO YUCCA MOUNTAIN, BY STATE, 2010-2048							
STATE	MOSTLY TRUCK	MOSTLY RAIL				MOSTLY RAIL (LOCAL)	
	Truck	Truck	Rail			Barge	HHT
AL	3,193	0	5,479			367	590
AZ	90,111	3,657	708			0	0
AR	963	0	395			0	0
CA	12,867	44	1,279			278	343
CO	27,612	1,013	14,968			0	0
CT	1,924	255	524			0	0
DE	1,992	0	0			362	0
FL	2,399	1,013	368			272	368
GA	15,150	1,013	4,889			0	0
ID	18,707	0	3,959			0	0
IL	57,100	3,278	12,648			0	0
IN	26,782	2,265	8,658			0	0
IA	32,869	2,644	7,427			0	0
KS	27,278	1,013	6,359			0	0
KY	20,566	1,013	5,600			0	0
LA	3,640	0	335			0	0
ME	356	0	60			0	0
MD	3,132	0	470			204	303
MA	2,080	476	864			0	0
MI	2,584	0	670			70	117
MN	1,184	379	221			0	0
MS	2,142	0	1,797			521	143
MO	26,570	1,013	6,359			159	114
NE	33,685	2,644	14,073			159	287
NV	92,851	3,701	19,845			0	19,845
NH	986	0	143			0	0
NJ	5,335	1,155	572			449	572
NM	7,609	0	358			0	0
NY	7,809	2,265	1,432			87	0
NC	4,618	0	1,259			0	0
OH	18,929	2,265	4,163			0	0
OK	4,663	0	833			0	0
OR	16,240	0	3,199			0	0
PA	17,763	2,265	3,866			0	403
SC	11,285	0	3,575			0	373
TN	20,566	1,013	5,600			0	0
TX	7,609	0	939			0	0
UT	80,004	3,657	18,508			0	0
VT	484	0	182			0	0
VA	1,981	0	311			128	144
WA	16,240	0	3,199			0	0
WV	5,269	0	311			0	0
WI	1,180	37	224			172	224
WY	33,685	2,644	13,482			0	0

The "mostly rail" scenario also affects 44 states, including Nevada, over a sustained period of 38 years. Forty-three states would be traversed by rail shipments, and 24 states would be traversed by both rail and legal-weight truck shipments. Additionally, 13 states could have barge shipments through their ports and waterways or HHT shipments on their public highways. Six states would be traversed by more than 13,900 shipments, an average of 366 shipments per year. Twenty-two states could be traversed by more than 1,980 shipments, or 52 shipments per year.

The states most heavily impacted by the "mostly truck" scenario are shown below in Table 2.1.5.

Table 2.1.5

State	Truck Shipments
NV	92,851
AZ	90,111
UT	80,004
IL	57,100
WY	33,685
NE	33,685
IA	32,869
CO	27,612
KS	27,278
IN	26,782
MO	26,570
TN	20,566
KY	20,566
OH	18,929
ID	18,707
PA	17,763
WA	16,240
OR	16,240
GA	15,150
CA	12,867

The states most heavily impacted by the "mostly rail" scenario are shown below in Table 2.1.6.

Table 2.1.6

State	Rail and LWT Shipments
NV	23,546
UT	22,165
NE	16,717
WY	16,126
CO	15,981
IL	15,926
IN	10,923
IA	10,071
KS	7,372
MO	7,372
KY	6,613
TN	6,613
OH	6,428
PA	6,131
GA	5,902
AL	5,479
AZ	4,365
ID	3,959
NY	3,697
SC	3,575

Truck shipments to Yucca Mountain would be a daily occurrence in major metropolitan areas like Atlanta, Nashville, Cleveland, and San Bernardino. Chicago would experience a truck shipment every 15 hours; St. Louis, Kansas City, and Denver, every 13 hours; Des Moines and Omaha, every 10 hours; and Salt Lake City, every 7 hours.

Table 2.1.7. Potential Truck Shipments Through Major Metropolitan Areas, 2010-2048

Metropolitan Area	Population 2000	Cumulative Shipments	Avg. Annual Shipments	Avg. Daily Shipments
Atlanta	4,112,198	15,150	399	1.1
Nashville	1,231,311	16,329	430	1.2
St. Louis	2,603,607	25,835	680	1.9
Kansas City	1,776,062	26,570	699	1.9
Denver	2,581,506	27,612	727	2.0
Cleveland	2,945,831	18,394	484	1.3
Chicago	9,157,540	22,541	593	1.6
Des Moines		32,869	865	2.4
Omaha	716,998	33,685	886	2.4
Cheyenne	53,011	33,685	886	2.4
Salt Lake City	1,333,914	52,392	1,379	3.8
Las Vegas	1,563,282	95,957	2,525	6.9

Truck shipments to Yucca Mountain would impact many of the fastest growing counties in the United States. Even in states that experienced little or no overall growth

between 1990 and 2000, Yucca Mountain transportation would impact the counties in those states that exhibited the highest growth rates. These are often bedroom communities and commercial/industrial parks along suburban interstate beltways. Ironically, the federal routing regulations (HM-164) tend to route shipments through these areas rather than through slower growing or declining downtown areas. Some examples are listed in the following tables. Notable examples are the counties along I-285 in Georgia, I-24 in Tennessee, I-270 in Missouri, I-80 in Illinois, Iowa, and Nebraska, I-70 in Colorado, and along I-10 and I-40 in Texas, New Mexico, Arizona, and California.

Table 2.1.8 Potential Truck Shipments Through Selected Urban Counties, 2010-2048

County/ State	Population 2000	Pop. Growth, 1990-2000	Likely Routes	Cumulative Shipments
Clark, NV	1,375,765	85.5	I-15, I-215	95,957
Maricopa, AZ	3,072,149	44.8	I-10	5,444
Mohave, AZ	155,032	65.8	I-15, I-40	84,667
Washington, UT	90,354	86.1	I-15	80,004
Salt Lake, UT	898,387	23.8	I-80, I-215, I-15	52,392
Utah, UT	368,536	39.8	I-15	52,392
Los Angeles, CA	9,519,338	7.4	I-5, I-210, I-10	2,760
San Bernardino, CA	1,709,434	20.5	I-10, I-15, I-40	12,867
Riverside, CA	1,545,387	32.0	I-10	5,444
Ada, ID	300,904	46.2	I-84	16,240
Cook, IL	5,376,741	5.3	I-80, I-94, I-294, I-88	22,541
Will, IL	502,266	40.6	I-80	21,513
Kendall, IL	54,544	38.4	I-80	21,513
Johnson, IA	111,006	15.5	I-80	
Polk, IA	374,601	14.5	I-80, I-35	32,869
Pottawattamie, IA	87,704	6.1	I-80, I-29, I-680	32,869
Douglas, NE	463,585	11.3	I-680, I-80	33,685
Sarpy, NE	122,595	19.5	I-80	33,685
Lancaster, NE	250,291	17.2	I-80	33,685
Fulton, GA	816,006	25.8	I-285	15,150
De Kalb, GA	665,865	21.9	I-20, I-85, I-285	11,417
Cobb, GA	607,751	35.7	I-285, I-75	15,150
Rutherford, TN	182,023	53.5	I-24, I-65	16,329
St. Charles, MO	283,883	33.4	I-270	25,835
Johnson, KS	451,086	27.1	I-435	26,570
Adams, CO	363,857	37.3	I-70	27,612
Dakota, MN	355,904	29.3	I-35E/W, I-494	1,147
Waukesha, WI	360,767	18.4	I-43	1,143
El Paso, TX	679,622	14.9	I-10	2,946

Risks of Routine Exposures from National HLW Transportation

Spent nuclear fuel is extremely radioactive. Extraordinary precautions and effective shielding are required in order to safeguard workers and the public from the lethal effects. A person standing one yard away from an unshielded, 10 year-old fuel assembly, for example, would receive a lethal dose of radiation (600 rem) in less than four minutes and would incur significant health damage within seconds.

The surface dose rate of spent fuel is so great (10,000 rem/hour or more) that shipping containers with enough shielding to completely contain all emissions are too heavy to transport economically. Consequently, NRC regulations allow a certain amount of neutron and gamma radiation to be emitted from shipping casks during routine operations and transport (1,000 mrem/hr at the cask surface and 10 mrem/hr 2 meters from the cask surface). Even when contained within a cask, SNF produces gamma and neutron radiation exposures up to one-half mile away.

SNF and HLW shipments to Yucca Mountain will contribute to the total radiation exposures received by transportation workers and members of the public. Radiation exposures (effective dose equivalents) are expressed in terms of rem³ or millirem (one-thousandth of a rem). The average American receives about 360 mrem annually from natural background and manmade sources. One hour of exposure at 2 meters (6.6 feet) from the side of a shipping cask produces about the same dose that a person receives from a whole body medical X-ray. For this reason, shipping casks have been called "portable X-ray machines that can't be turned off."

The precise relationship between low-level radiation exposures and adverse health effects is a matter of continuing debate within both the medical and the health physics communities. Advocates of the linear no-threshold hypothesis believe that all radiation exposures may result in adverse health effects. Many other experts believe that no significant health effects occur until exposures exceed 300-1,000 mrem. The International Commission on Radiological Protection recognizes different radiation health risks for different groups among the public, including young children and pregnant women.

The dose rate allowed under NRC regulations results in near-cask exposures of about 2.5 mrem per hour at 5 meters (16 feet), in measurable exposures (about 0.01 mrem per hour) at 25-30 meters (80-100 feet), and calculated exposures (0.000002 mrem per hour) at 800 meters (one-half mile) from the cask surface. Cumulative exposures at these rates can result in adverse health affects for some workers and some members of public. Moreover, the very fact that these exposures occur has been shown to cause adverse socioeconomic impacts, such as loss of property values, even though the dose levels are well below the established thresholds for cancer and other health effects.

Routine radiation from shipping casks poses a clear health threat to certain transportation workers. Safety inspectors, truck drivers, and rail crews could receive

³ The DEIS [p. 3-81] defines Rem: "The dose of an ionizing radiation that will cause the same biological effect as one roentgen of X-ray or gamma ray exposure (rem means Roentgen Equivalent in Man)."

cumulative doses large enough to increase their risk of cancer death by up to 15 percent, and their risk of other serious health effects by 50 percent or more. DOE proposes to control these exposures and risks by limiting work hours and doses.

Routine radiation from shipping casks poses a potential health threat to certain members of the public. Service station attendants could receive 100-1,000 mrem doses per year. Motorists could receive 40 mrem during a traffic gridlock incident. Residents near rail yards, truck stops, and certain routes used by SNF and HLW shipments could receive 5-45 mrem per year. Such exposures could increase the risk of certain health effects, such as mental retardation in unborn children and genetic damage in future generations.

Routine radiation from passing casks will deliver small radiation doses to members of the public within one-half mile of highway and rail routes. Nationally, 7-11 million people reside within one-half mile of a truck or rail route. Even though these dose levels are well below the established thresholds for cancer and other health effects, research shows that the mere presence of sustained numbers of such shipments through communities can devalue – and have devalued – property by as much as 4.75 percent. Applied nationally, the economic impacts of such devaluation would be incalculable.

Accident Risks and Impacts from National Transportation of SNF and HLW

Likelihood of SNF and HLW Accidents Occurring

Development of a Yucca Mountain repository would result in the largest, most ambitious, and longest duration SNF and HLW shipping campaign in history. Past performance on the part of the nuclear industry is no assurance that future Yucca Mountain shipments would be safe. Indeed, if future shipments were to experience accidents and regulatory incidents at the same rate as past shipments, the resulting socioeconomic impacts would be unacceptable, even without any releases of radioactive materials.

DOE and the nuclear power industry are quick to point to their record of safely shipping limited quantities of spent fuel during the past 30 years. What DOE and the industry do not publicize is that, prior to 1971, there were, in fact, transportation accidents and incidents that resulted in radiation releases. Between 1957 and 1964, there were 11 transportation incidents and accidents involving spent fuel shipments by the US Atomic Energy Commission and its contractors. Several of these incidents resulted in radioactive releases requiring cleanup, including leakage from a rail cask in 1960 and leakage from a truck cask in 1962. There is no comparable data for the period from 1964 to 1970, when utility shipments to reprocessing facilities began.

Between 1971 and 1990, there were six accidents and 47 regulatory incidents involving spent fuel cask shipments. Most of the regulatory incidents involved excess radioactive contamination of cask surfaces (often referred to as "weeping"), but a few involved violations that could have contributed to increased accident risks. Three

accidents (two truck, one rail) involved casks loaded with spent fuel. Fortunately, no radioactivity was released in these accidents, although one truck accident was severe enough to kill the driver. However, the record clearly indicates that accidents do happen and that the potential for accidents involving radiation releases exists.

A DOE contractor report evaluated these SNF accidents and incidents and developed historical SNF accident and incident rates for use in projecting the impacts of future shipments to a Yucca Mountain repository. These accident and incident rates have not changed appreciably because of the relatively small number of shipments and shipment-miles during the 1990s. DOE chose to ignore this information in preparing the transportation impact analysis for the Yucca Mountain DEIS.

State of Nevada staff and contractors have evaluated the potential for future transportation accidents and incidents during SNF and HLW shipments to Yucca Mountain.⁴ The Nevada analysis applied the actual accident and incident rates from past shipments to the projected shipment numbers and distances that would result under DOE's "mostly truck" and "mostly rail" scenarios and under the Nevada "current capabilities" scenario. The Nevada analysis concludes that 130 - 400 accidents and 900 - 1,900 regulatory violations would be expected over 38 years if future shipments were to be as safe as past shipments. Table 2.1.9 shows the results for each scenario.

Table 2.1.9 Projected Repository Transportation Accidents and Incidents, 2010-2048.

Scenario & Mode	Shipments	Shipment-Miles	Accidents	Incidents
<i>Mostly Truck</i>				
Truck	92,871	184,228,600	129	1,934
Rail to NV	300	197,400	2	4
HHT in NV	300	34,100	Not Available	Not Available
<i>Mostly Rail</i>				
Truck	3,701	9,789,800	7	103
Rail to NV	19,643	39,263,000	381	762
Rail in NV	6,548	2,088,700	20	41
<i>Current Capabilities</i>				
Truck	26,375	60,851,300	43	640
Rail to NV	13,969	26,613,200	258	516
Rail in NV	4,656	1,485,300	15	30

By relying upon past accident and incident rates, the Nevada analysis may actually underestimate the potential for accidents and incidents during shipments to Yucca Mountain. In the past, limited numbers of spent fuel shipments have been made

⁴ The Nevada analysis assumed that rail casks would be shipped to Nevada individually in general freight service, and that rail shipments from a Nevada interchange facility would be made in dedicated trains consisting of three cask cars on average. There was not sufficient data to accurately project accidents and incidents involving barge shipments of SNF from reactors to port rail facilities, or HHT shipments from reactors to railheads, or HHT shipments from an intermodal transfer facility in Nevada to Yucca Mountain. [Ref. R.J. Halstead, "Projected Accidents and Incidents During SNF and HLW Shipments to Yucca Mountain, 2010-2048," Memorandum Report, January, 2002.]

between and among utilities and to and from storage and research facilities. Shipping campaigns rarely involved more than a few shipments at a time. The average distance of past shipments was less than 600 miles. For Yucca Mountain shipments, the average distance traveled would be over 2,000 miles, creating many more opportunities for human error and equipment failure.

The precautions taken for historical shipments have often been far beyond what is minimally required by regulation. This was possible because the shipments were usually one-time or limited-duration events. In the case of Yucca Mountain, there would be tens of thousands of spent fuel and high-level waste shipments continuously for four decades or more. DOE has stated its intention to operate the Yucca Mountain transportation system based on existing regulatory standards. In the case of rail shipments, DOE's plans actually call for spent fuel casks to be shipped in mixed freight trains, instead of in secure and specially regulated dedicated trains.

DOE is proposing to use a privatized, market-driven system for Yucca Mountain transportation services. Under the DOE approach, cost would constantly be competing with safety when contractors make decisions regarding mode and route selection, frequency of inspections, and other important operating protocols. Fixed-cost contracts will make it difficult to afford the same level of care and attention to each Yucca Mountain shipment that was afforded to utility and DOE shipments of the past.

National Impacts from Severe Transportation Accidents

Each truck shipment to Yucca Mountain would carry an enormous inventory of deadly radioactive materials. Each rail cask shipped to Yucca Mountain would carry four to six times as much highly radioactive material as a truck cask. Casks are not designed to withstand all credible rail and highway accidents. An accident that released even a small fraction of a truck cask inventory could cause catastrophic health and economic impacts. A severe rail accident resulting in a release of cask contents could have adverse health and economic impacts many times greater than a truck accident.

The Yucca Mountain DEIS acknowledged that a very severe highway or rail accident could release radioactive materials from a shipping cask, resulting in radiation exposures to members of the public and latent cancer fatalities (LCFs) among the exposed population. DOE did not evaluate non-cancer health effects and ignored alternative dose risk factors that could have increased the LCF estimate sevenfold. Moreover, DOE completely ignored the potential economic impacts of severe accidents. The cost of cleanup, evacuation, and business loss resulting from a severe transportation accident in a generic urban area could range from several billion to several hundred billion dollars.

The DEIS evaluated what DOE considered to be a maximum reasonably foreseeable accident scenario involving a truck accident at a generic urban location. Following the accident severity categories designated by the NRC Modal Study, DOE estimated the consequences of the most severe (Category 6) truck accident using the

RISKIND computer code. The DOE analysis used weather and demographic inputs based on U.S. national average data and assumed that the maximum long-term exposure following the accident would be one year. DOE assumed the truck cask would be loaded with PWR SNF cooled about 26 years prior to shipment, although NRC regulations would allow shipment of much more dangerous 5-year-cooled SNF.

DOE estimated that the maximum severe truck accident would release and disperse enough radioactive materials to inflict a collective population dose of 9,400 person-rem (that is, enough to give 9,400 persons a one rem dose) and cause about 5 latent cancer fatalities. DOE estimated the probability of such an accident at 1.9 in 10 million per year. Less severe truck accidents (Category 5), also resulting in releases, had estimated probabilities for rural and urban locations ranging from 4 in 100,000 to 3 in 10 million per year.

The DEIS similarly evaluated what DOE considered to be a maximum reasonably foreseeable accident scenario involving a rail accident at a generic urban location. As with the truck accident, DOE evaluated a Category 6 rail accident using RISKIND and the same weather, population, and exposure time assumptions. DOE also assumed the rail cask would be loaded with 26-year-cooled PWR SNF, although rail casks are currently designed to transport more dangerous 10-year-cooled SNF and could be designed for 5-year-cooled SNF.

DOE estimated that the maximum severe rail accident would release and disperse enough radioactive materials to inflict a collective population dose of 61,000 person-rem (enough to give 61,000 persons a one rem dose) and cause about 31 latent cancer fatalities. DOE estimated the probability of such an accident at 1.4 in 10 million per year. Less severe rail accidents (Category 5), also resulting in releases, had estimated probabilities for rural and urban locations ranging from 4 in 100,000 to 7 in 10 million per year.

For this impact report, the State of Nevada commissioned several SNF accident consequence analyses by Radioactive Waste Management Associates (RWMA). In 2000, RWMA reexamined the DEIS truck and rail accident estimates, using the RADTRAN and RISKIND computer models and a range of credible alternative assumptions. In 2001, RWMA estimated the consequences of a SNF rail accident similar to the July 2001 Baltimore rail tunnel fire. Also in 2001, RWMA studied the consequences of credible worst case truck and rail accidents at representative urban and rural locations along potential Nevada highway routes. The Nevada accident analyses are reported in Chapter 3 of this report.

RWMA first replicated the DEIS accident health consequence analyses with RISKIND, and then repeated the analyses using a range of values for SNF age (10 years and 25.9 years), weather conditions (weighted average of all stability categories) and dispersion models, evacuation time (1 day and 7 days), and long term exposure (1 year and 50 years). RWMA concluded that the number of expected latent cancer fatalities

could be up to 40 times higher than the DOE estimates. The RWMA results from RISKIND are reported in Table 2.1.10

Table 2.1.10 Comparison of Truck and Rail Accident Consequences

Long-term Exposure Time (years)	Spent Fuel Age (years)	Atmospheric Dispersion Model	Expected Latent Cancer Fatalities: Truck Accident	Expected Latent Cancer Fatalities: Rail Accident
1	25.9	Pasquill-Gifford	15.9	109
50	25.9	Pasquill-Gifford	135	933
1	10	Pasquill-Gifford	20.8	144
50	10	Pasquill-Gifford	199	1,370
1	25.9	Effective Release ht.	4.6	30.8
50	25.9	Effective Release ht.	38.8	262
1	10	Effective Release ht.	5.96	40.3
50	10	Effective Release ht.	57	386

Source: RWMA, "Health Consequence Assessment: Severe Truck Accident in An Urban Area," June 28, 2000.

RWMA also replicated the DEIS accident health consequence analyses with RATRAN4 and RADTRAN5, and then repeated the analyses using similar range of values for SNF age, weather conditions and dispersion models, evacuation time, and long term exposure. RWMA used the resulting outputs and the RADTRAN models to estimate the economic impacts of the reference truck and rail accidents. RWMA concluded:

"The results of our analysis suggest that the health and economic consequence estimates calculated by the RADTRAN program vary greatly with assumed meteorological conditions and spent fuel age. The results of both the truck and rail consequence assessments indicate that the greatest economic damage would occur from a severe accident occurring under stability category D-E meteorological conditions. Under these circumstances, vertical atmospheric motion is suppressed, resulting in less dispersion of released contaminants. It appears that stability category F conditions resulted in lower estimated economic costs because the atmosphere under those conditions limited dispersion to a highly concentrated zone in which the released contaminants were confined. Thus, there was much less area contaminated by the release than there was under more dispersive meteorological conditions, resulting in lower economic costs.

For the most economically severe rail accident in an urban area under weighted average meteorological conditions, our RADTRAN 5 analysis has estimated the associated costs to be on the order of \$270 billion for 10-year-cooled fuel and \$145 billion for 25.9-year-cooled fuel, present-day value. For the most economically severe truck accident, our RADTRAN 5 analysis has estimated the associated costs to be on the order of \$36.6 billion for 10-year-cooled fuel and \$20.1 billion for 25.9-year-cooled fuel. We need to underline the fact that the economic costs could be 3 to 4 times greater if one assumed a realistic urban population density.

It is also important to realize that the economic models utilized here make no attempt to include all of the costs associated with the remediation of a severe accident involving a release of radioactive material. They also make no attempt to provide a means of estimating the costs associated with an accident in a specific city. For example, in tourism-driven cities such as Las Vegas, the economic losses stemming from stigma effects would likely be staggering, but are not included in our estimates and are beyond the scope of this report." [RWMA, "Updated Rail and Truck Accident Economic Analysis," July 7, 2000]

The State of Nevada commissioned a study by RWMA of the July 18-23, 2001 Baltimore rail tunnel accident and fire. Preliminary information suggested that the Baltimore accident might be comparable to the Modal Study's Category 5 or Category 6 accidents, which could result in a significant release of cesium-134 and cesium-137. Since current U.S. Department of Transportation (USDOT) regulations allow SNF casks to be shipped in mixed freight trains, it was credible to assume that one or more SNF casks could have been part of such a train. Moreover, the accident occurred on a route identified in the DEIS as a potential corridor for rail shipments of SNF from the Calvert Cliffs reactor to Yucca Mountain.

RWMA concluded that the Baltimore rail tunnel fire burned for three days with temperatures as high as 1500 degrees Fahrenheit, creating a Category 6 accident fire environment sufficient to cause a breach of the cask and a significant release of radiocesium and other radionuclides. RWMA evaluated the potential consequences of an identical accident including a rail cask loaded with 10-year-cooled SNF. RWMA used the RISKIND and HOTSPOT computer models, weather data from Baltimore-Washington International Airport, and Baltimore population data from the 2000 Census. Figures 2.1.9, 2.1.10, and 2.1.11 show the areas receiving radiation doses during the first 24 hours, during the following fifty years, and the contaminated areas requiring cleanup.

Figure 2.1.9

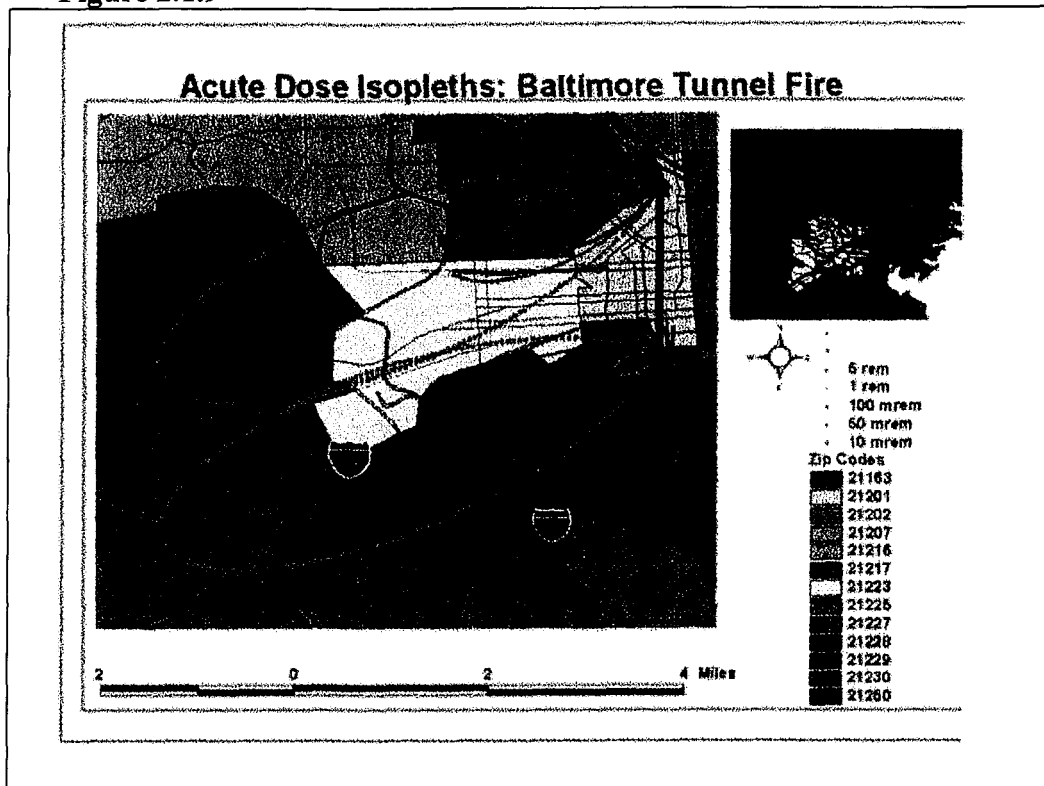


Figure 2.1.10

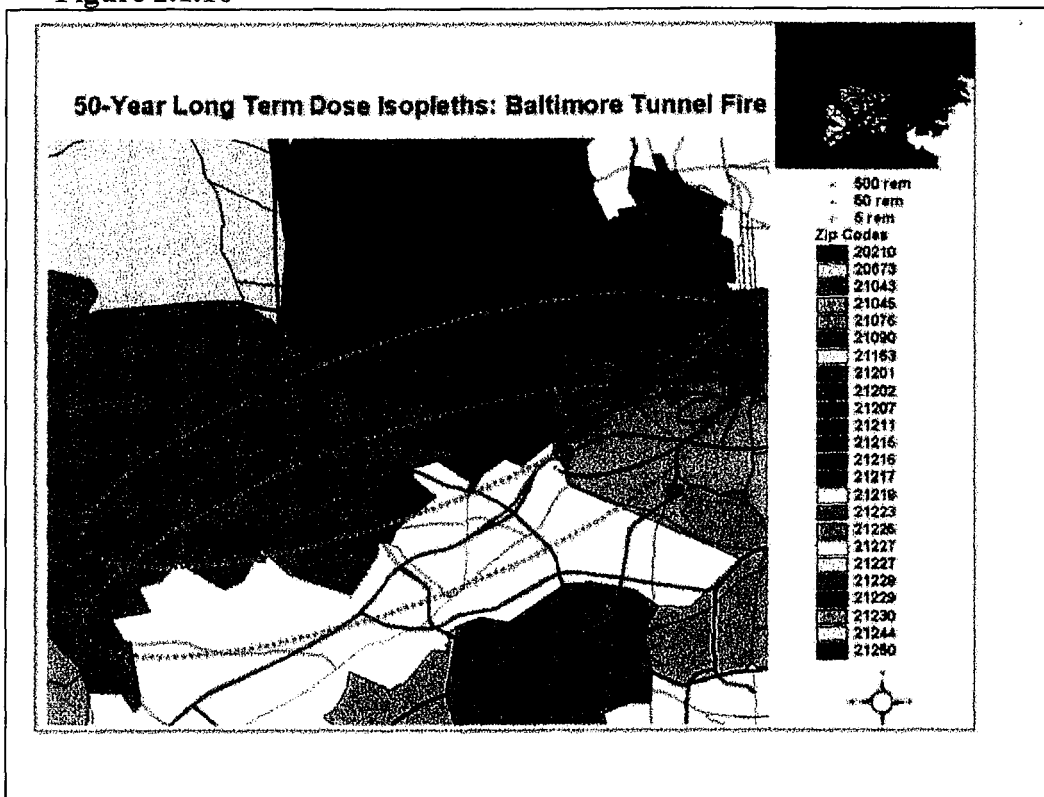


Figure 2.1.11

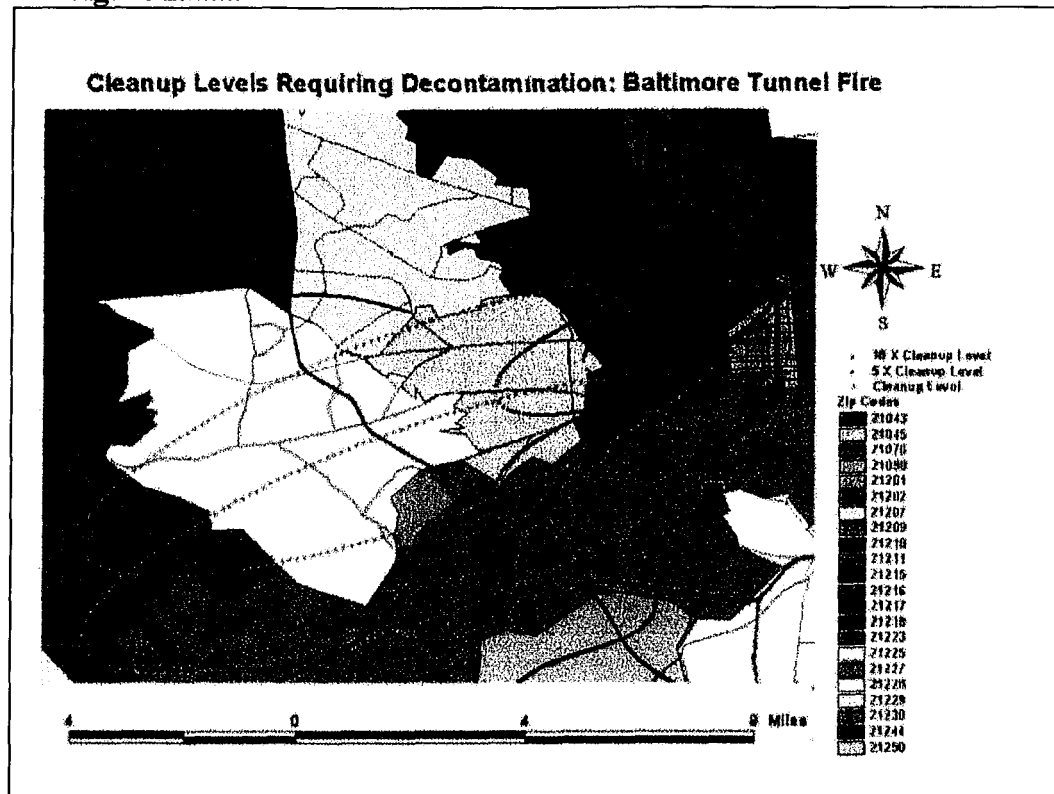


Table 2.1.11, below, presents the results of the differing scenarios for short-term (24-hour) exposure, 1-year exposure, and 50-year exposure. It is important to note that the exposure estimates assume no evacuation or cleanup, in order to provide a bounding result.

Table 2.1.11 Results: Evaluation of Baltimore Tunnel Fire with Hypothetical Spent Fuel Cask

	Baltimore Residents	PCINet Stadium if filled to capacity during incident
Affected Population, 1990 (2000)	390,388 (345,493)	69,400
Area with acute dose of at least 10 mrem	11.0 km ²	11.0 km ²
Max. Downwind Distance of 10 mrem acute dose plume	6.8 km	6.8 km
Area with acute dose of at least 1 mrem	173 km ²	173 km ²
Max. Downwind Distance of 1 mrem acute dose plume	38.7 km	38.7 km
Acute Population Dose, 1990 (2000) [person-rem]	17,509 (15,495)	38,170
Range of Estimated Excess Latent Cancer Fatalities from Acute Dose, 1990 (2000)	9-56 (8-50)	19-122
1-Year Population Dose, 1990 (2000) [person-rem]	495,498 (438,516)	--
Range of Estimated Latent Cancer Fatalities from 1-year Dose, 1990 (2000)	248-1,586 (219-1,403)	--
50-Year Population Dose, 1990 (2000) [person-rem]	9,944,974 (8,801,302)	--
Range of Estimated Latent Cancer Fatalities from 50-year Dose	4,972-31,824 (4,401-28,164)	--

Table 2.1.12 below shows RWMA's estimate of cleanup costs. These cleanup cost estimates would be significantly greater if meteorological conditions were different. For example, a higher wind speed or more stable atmospheric conditions would have contributed to a greater downwind dispersal and, consequently, greater contaminated areas.

Table 2.1.12 Decontamination Cost Estimates: Baltimore Tunnel Fire Spent Fuel Accident

Area heavily contaminated (km ²)	9.9
Area moderately contaminated (km ²)	10
Area lightly contaminated (km ²)	62.4
Cost/km ² , heavy contamination	\$394,604,748
Cost/km ² , moderate contamination	\$182,592,165
Cost/km ² , light contamination	\$128,263,609
Total Cleanup Costs*	\$13.7 billion

*Total cleanup costs are the sum of light, moderate, and heavy cleanup costs, all in 1995 dollars.

RWMA concluded that the Baltimore accident conditions were severe enough to have caused the largest release considered in the DEIS for the Yucca Mountain facility. The contamination resulting from the release would cause a policy-maker's nightmare. On the one hand, the cost of cleanup could be \$13.7 Billion. On the other hand, failure to clean up could result in up to 1,580 latent cancer fatalities over one year, and up to 31,800 latent cancer fatalities over 50 years. The potential health and economic consequences presented give some indication of the tradeoff likely to take place between preventing future health effects and expending a large amount of money to properly remediate an area.

An additional matter concerns the potential stigma effects that would undoubtedly result from an accident resulting in the radioactive contamination of a major portion of Baltimore, including the locations of its professional sports arenas. These effects, though real and likely more economically devastating than the costs estimated by RWMA, are difficult to quantify. RWMA concluded that an accident involving a release of radioactive material from a transportation container could be economically devastating.

National Risks from Terrorism and Sabotage

Well before the terrorist suicide attacks of September 11, 2001, research conducted by the State indicated that past NRC and DOE evaluations of the terrorist threat against SNF and HLW shipments were seriously deficient. Two Nevada contractor reports published in 1997 documented recent changes in the nature of the terrorist threat and the increased vulnerability of shipping casks to terrorist attacks involving high-energy explosive devices. The State of Nevada filed a petition for rulemaking with the NRC in June 1999, requesting that the NRC completely reexamine the issue of terrorism and sabotage relative to repository shipments of SNF and HLW. Nevada's comments on the Yucca Mountain DEIS advised DOE that the DEIS sabotage scenario was unreasonably constrained, and the impacts of that scenario were insufficiently evaluated. As of February 2002, neither NRC nor DOE has responded to Nevada's evidence regarding the vulnerability of SNF shipments, nor to Nevada's contention that shipments to a geologic repository will be dramatically different from past shipments in the United States, and that these differences will create greater opportunities for terrorist attacks and sabotage.

SNF truck casks are especially vulnerable to terrorist attack and sabotage. DOE and NRC testing in the 1980s demonstrated that a high-energy explosive device (HED), such as a military demolition charge, could breach the wall of a truck cask. DOE sponsored a 1999 study of cask sabotage by Sandia National Laboratories (SNL) in support of the DEIS. The SNL study demonstrated that HEDs are "capable of penetrating a cask's shield wall, leading to the dispersal of contaminants to the environment." [DEIS, p. 6-33] The SNL study also concluded that a successful attack on a truck cask would release more radioactive materials than an attack on a rail cask. [DEIS, p. 6-34]

The DEIS estimated that a successful attack on a GA-4 truck cask in an urban area under average weather conditions would result in a population dose of 31,000

person-rem, causing about 15 cancer fatalities among those exposed to the release of radioactive materials. The maximally exposed individual would receive a dose of 67 rem. The DEIS did not evaluate any environmental impacts other than health effects. In particular, the DEIS ignored the economic impacts of a successful act of sabotage.

An analysis prepared for Nevada by RWMA estimated sabotage impacts would be at least ten times greater than DOE's estimate. RWMA replicated the DEIS sabotage consequence analysis, using the RISKIND model for health effects and the RADTRAN model for economic impacts, the SNL study average and maximum inventory release fractions, and a range of population densities and weather conditions. Under average weather conditions, RWMA estimated that the same sabotage incident would result in 6-104 latent cancer fatalities and a maximum individual acute dose of 196 rem. Under worst case weather conditions, there would be 14-165 latent cancer fatalities and a maximum individual acute dose of 324 rem. Cleanup costs and other economic impacts ranged from \$3.1-13.5 billion (2000\$) for average weather conditions, and \$10.1-20.9 billion (2000\$) for worst case weather conditions.

Other terrorism and sabotage scenarios could result in even more severe impacts. The Sandia study assumed that the reference weapon would not completely penetrate the cask. Full perforation would increase the release and resulting consequences by a factor of ten. The impacts would have also been substantially greater if the cask was assumed to be carrying 5-year-old SNF. DOE assumed 26-year-old SNF. DOE also failed to consider credible attack scenarios involving the use of more than one penetrating weapon, use of an incendiary device in conjunction with a penetrating weapon, and use of commercial shaped charges that are more efficient metal penetrators than the M3A1 military demolition device evaluated by SNL.

The social and economic impacts of an attempted act of terrorism or sabotage, whether successful or unsuccessful, deserve special attention. An incident involving an intentional release of radioactive materials, especially in a heavily populated area, could cause widespread social disruption and substantial economic losses even if there were no immediate human casualties and few projected latent cancer fatalities. Local fears and anxieties would be amplified by national and international media coverage. Adverse economic impacts would include the cost of emergency response, evacuation, decontamination and disposal; opportunity costs to affected individuals, property-owners, and businesses; and economic losses resulting from public perceptions of risk and stigma effects.

Concern about terrorism impacts led Nevada's Attorney General to file a petition for rulemaking with the NRC in June 1999. The petition requested a general strengthening of the current transportation safeguard regulations and a comprehensive reexamination of the consequences of radiological sabotage against SNF shipments. The NRC published the petition (Docket PRM-73-10) in the Federal Register on September 15, 1999. More than 20 parties, including 11 States, filed comments on the petition. The NRC has not officially responded to Nevada as of January 2002.

The petition documented developments that have increased the vulnerability of shipping casks to terrorist attacks involving high-energy explosive devices over the past decade and a half. First, the capabilities and availability of explosive devices, especially antitank weapons and commercial shaped charges, have increased significantly. Second, new spent fuel shipping cask designs, developed to increase payloads without exceeding specified weight limits, appear to be more vulnerable to attacks involving past, current, and future military weapons systems and civilian explosives.

The petition submitted evidence that spent nuclear fuel shipments to a national repository or storage facility will be dramatically different from past shipments in the United States. The following differences will create greater opportunities for terrorist attacks and/or sabotage against SNF shipments and may also increase the consequences of any incidents that occur:

- (a) Long-duration, highly visible, nationwide shipping campaign;
- (b) Regular and predictable shipments to a single destination;
- (c) Large increase in amount of spent fuel shipped and increased numbers of truck and rail shipments annually, averaging several cask shipments per day, every day, for 30 years;
- (d) Substantial increase in number of active routes and average shipment distances, with potential implications for selection of targets and attack locations;
- (e) Significant concentration of shipments along certain highway and rail routes west of the Mississippi River, with implications for shipments through heavily populated areas and through locations that place shipments in significantly disadvantageous tactical positions; and
- (f) Potential use of routes within Nevada with marginal safety design features, limited rest and refueling locations, and low likelihood of swift local law enforcement agency response.

The petition also pointed out that a national repository or storage facility may have a greater symbolic value to terrorists than current at-reactor storage facilities, and that the enhanced symbolic value of the facility as a target may extend to SNF shipments to such a facility. Facilities operated by DOE, the U.S. government agency responsible for producing nuclear weapons, may have greater symbolic value as terrorist targets than commercial nuclear facilities. Two Rand Corporation studies found that DOE nuclear programs may be especially attractive targets for state-sponsored terrorists and domestic right-wing radicals.

The events of September 11th indicate that further reconsideration of potential terrorist attack scenarios is necessary. Nevada previously urged the NRC and DOE to

assess of the consequences of attacks against transportation infrastructure used by nuclear waste shipments, attacks involving capture of a nuclear waste shipment and use of high energy explosives against the cask, and direct attacks upon a nuclear waste shipping cask using antitank missiles. It is now apparent that the risk assessment must consider suicide attacks involving large groups of well-trained adversaries, and previously unanticipated attack modes such as use of hijacked commercial airplanes, tanker trucks, and military vehicles and aircraft.

The events of September 11th reemphasize the importance of comprehensively assessing the consequences of a successful attack. Nevada previously requested that the NRC and DOE assess the full range of human health, environmental, and socioeconomic impacts of a terrorism or sabotage event resulting in a release of radioactive materials. The post-September 11th recovery efforts in New York and Virginia demonstrate the importance of addressing standard socioeconomic impacts, including cleanup and disposal costs and opportunity costs to affected individuals and business, as well as so-called special socioeconomic impacts, including individual and collective psychological trauma, and economic losses resulting from public perceptions of risk and stigma effects. The necessity of addressing impacts on emergency responders and recovery workers is now also clear.

Finally, the events of September 11th underscore the importance of immediately adopting a national policy to protect, in place, the SNF currently stored at commercial nuclear power plants. Existing wet and dry storage facilities will require protection from terrorist attack for the next 40 years, regardless of current proposals for centralized storage or geologic disposal. Protection of SNF at existing facilities is a straightforward task. Existing technologies and tactics can readily turn wet and dry storage installations into hardened targets. Protection of SNF shipments is an entirely different matter. From the standpoint of target attractiveness and vulnerability, shipping SNF to a national repository or centralized storage site will only increase the risk of terrorism and sabotage. (Ballard, 2002) Even if such shipments were to begin within the next decade, it would then be necessary to protect both the storage facilities and the shipments for four decades or more.

Conclusion

State of Nevada research has documented that there are substantial risks to communities located along potential shipping routes from the transport of spent nuclear fuel and high-level waste to a repository in Nevada. These risks are significant “drivers” of the entire array of socioeconomic and related impacts associated with the federal program. DOE’s and the federal government’s activities in the area of transportation analysis, planning, and risk management have done little to attenuate these risks and, instead, have either obfuscated or actually exacerbated risks and their consequences.

Not only are the risks from spent fuel and high-level waste shipments potentially great, but also they are also unnecessary. These materials have long been, and are currently being, stored in safe, secure, fixed locations where risks are minimized. With

currently available dry storage technology, spent fuel can continue to be safely and economically stored on site for the next 100 years or more. Exposing millions of people in 44 states to needless risks from the transportation of these materials is entirely unwarranted.

2.2 National Transportation Impacts on Native American Communities

Native American communities and Indian Reservations in 16 states besides Nevada would be directly impacted by shipments of spent nuclear fuel and high-level nuclear waste to Yucca Mountain. Figure 2.2.1 depicts the Indian reservations identified as being directly impacted by one or more of the rail and truck routes contained in DOE's DEIS.

Figure 2.2.1 Tribes or Reservations Impacted by National SNF and HLW Shipments

STATE	TRIBES OR RESERVATIONS	ROUTES
Arizona	Hualapai and Navajo	I-10, I-40; BNSF/UPRR
California	Agua Calientes, Cabazon, Chemehuevi Valley, Ft. Mojave, Ft. Yuma, Morongo, Torres Martinez, and Hoopa Valley	I-10, I-40/I-15; SF/UPRR
Florida	Hollywood	I-95, FECR
Idaho	Fort Hall	I-15, UPRR
Iowa	Mesquakie(Sac & Fox)	UPRR
Kansas	Potawotamie	UPRR
Minnesota	Prairie Island	CP/Soo
Nebraska	Omaha and Winnebago	UPRR
New Mexico	Acoma, Canoncito, Isleta, Laguna, Navajo, and Zuni	I-10, I-40; BNSF/UPRR
New York	Cataraugus and Tonawanda	I-90, Conrail
North Carolina	Cherokee	I-40
Oklahoma	Choctaw, E. Shawnee, Kialegee Creek, Kickapoo, Miami, Modoc, Osage, Ottawa, Peoria, Quapaw, Sac & Fox, and Thlopthlocco Creek	I-35, I-40; BNSF/UPRR
Oregon	Umatilla	I-84; UPRR
Utah	Goshute, Ouray, Skull Valley, and Unitah	I-84/I-15/I-80/US93A; UPRR
Washington	Yakima	I-84; UPRR
Wisconsin	Oneida	WCRR

Except for Tribes in Idaho, DOE failed to identify any potentially affected Indian reservations and communities in the DEIS and in notices for public hearings on the DEIS. DOE further failed to provide financial assistance to facilitate independent technical review of the DEIS by potentially affected Indian Tribes.

The State of Nevada has defined transportation-affected Native American lands and resources to included the following:

- (1) Reservations crossed by potential shipping routes;
- (2) Off-reservation ceded lands, where Tribes retain treaty rights or other legally-recognized user rights, crossed by potential shipping routes;
- (3) Reservation lands and off-reservation lands within transportation emergency evacuation zones along potential shipping routes;
- (4) Reservation and off-reservation lands that could be contaminated by air or water transport of radioactive materials released in a severe transportation accident or terrorist incident (generally within 50 miles downwind, downstream, or downgradient of a potential shipping route);
- (5) Reservations whose highway access would be disrupted by a nuclear waste transportation emergency; and
- (6) Off-reservation lands along potential shipping routes where Tribal personnel would likely be involved in transportation emergency response.

The Yucca Mountain DEIS gives insufficient consideration to the major concerns identified by potentially affected Indian Tribes and by the National Congress of American Indians. These concerns include:

- (1) Tribal authority to regulate shipments across reservations;
- (2) emergency response planning and training for Tribal personnel;
- (3) advance notification of shipments and shipment monitoring;
- (4) protection of Native American religious and cultural sites, plants, and animals, both on and off reservations;
- (5) cultural implications of potential radiological contamination of Indian lands, and the cultural implications of cleanup activities involving non-tribal personnel; and
- (6) adverse economic impacts of public perception of risk, especially adverse impacts on tribal tourism and recreation businesses.

2.3 Cost Impacts of the Yucca Mountain Program

In 1998, in order to effectively evaluate the accuracy and appropriateness of DOE's cost estimates for the high-level waste program, the State of Nevada commissioned an independent study of likely costs associated with accepting SNF and HLW at generator sites, transporting the material to Nevada, and ultimately disposing of it in a repository.

The study addressed the entire range of activities associated with the highly complex federal program, including DOE responsibility for at-reactor storage pending shipment, waste acceptance activities, transportation planning and emergency preparedness, shipping assumptions and intermodal transportation, centralized interim storage, repository disposal, and other related aspects of the system. The objective was to understand the *real* costs of the program in their totality, rather than approaching cost assessment in an incomplete and often piecemeal fashion as DOE had done in prior assessments.

To assure that the Nevada study would be as accurate and objective as possible, a team of independent consultants was employed to gather information, analyze the data, and develop the ultimate cost conclusions. The accounting firm of KPMG Peat Marwick was commissioned to provide expert peer review of the effort.

The result of this extraordinary independent undertaking was a comprehensive and timely evaluation of the real costs to the nation of the federal high-level nuclear waste program - not just the Yucca Mountain repository component - and the potential taxpayer liability the country would incur as that program moves forward. The full report is attached as Appendix IX to this report.

The findings of the State of Nevada cost assessment are summarized in seven categories, as shown in Table 2.3.1.

Table 2.3.1 Overview of Total System Life Cycle Costs by Major Cost Categories

Major Cost Categories	Cost (bil FY'96\$)
Expenditures Through Fiscal Year 1996	6.1
Estimated Future Costs	47.8
1. Onsite Storage	4.3
2. Cross-Country Transportation	6.0
3. Nevada Transportation	3.2
4. Centralized Interim Storage Facility	9.2
5. Geological Repository	23.0
6. Other Development and Evaluation Costs	0.4
7. Other Program Costs	1.7
Total	\$53.9

It should be noted that, in 1998, when the State's cost assessment was done, DOE's estimate for the total life cycle cost of the federal program was approximately

\$43.7 billion. In 2001, DOE released a revised TLCC analysis that put the costs of the program at \$57.5 billion (expressed in FY 2000 dollars). If the State estimate were updated using 2000 dollars, the figure would be in the neighborhood of \$60 billion, very close to DOE's current estimate.

DOE estimates that the Nuclear Waste Fund (current balance and future revenues) would produce \$41.8 billion in constant 2000 dollars.⁵ Even if DOE's waste fund estimate were accurate, this would leave a potential taxpayer liability of over \$18 billion, a figure that is very likely to grow as Nuclear Waste Fund revenues shrink and program costs escalate, as they inevitably would in a project of this magnitude and complexity.

Implications

The cost-revenue condition of the nation's HLW program and the potential for costly uncertainties are major causes for concern and are of potentially significant impact for the nation as a whole. The key implications are that the probable costs of managing the nation's HLW and the liability for the general taxpayer are substantially greater than have been estimated. The Nuclear Waste Fund under its current fee structure would leave the country with a major unfunded liability that has not been accounted for in expenditure/revenue calculations for the federal budget.

⁵ The estimates of revenues from civilian nuclear power plants are based on projected electric generation of existing stations, which are expected to operate in gradually reduced numbers until all currently operating reactors would have completed their license terms. There is some uncertainty about operating projections since several plants already have shut down early and others have applied for license extensions. Any early shutdowns reduce revenues on a one-to-one basis for each kilowatt of power not produced, but the reduced amount of spent fuel reduces costs only at the margin of a program that must be developed in any case. In light of the events of September 11th, it is difficult to see new nuclear power plants coming on line in the foreseeable future, given the heightened public concern over the terrorism risks posed by these high profile and potentially vulnerable facilities.